



King's Research Portal

DOI:

[10.1016/j.oooo.2018.09.001](https://doi.org/10.1016/j.oooo.2018.09.001)

Document Version

Peer reviewed version

[Link to publication record in King's Research Portal](#)

Citation for published version (APA):

Shokouhi, B., Thavaraj, S., Sproat, C., Kwok, J., Beneng, K., & Patel, V. (2018). Coronectomy Root Retrievals: A review of 92 cases. *Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontics*.
<https://doi.org/10.1016/j.oooo.2018.09.001>

Citing this paper

Please note that where the full-text provided on King's Research Portal is the Author Accepted Manuscript or Post-Print version this may differ from the final Published version. If citing, it is advised that you check and use the publisher's definitive version for pagination, volume/issue, and date of publication details. And where the final published version is provided on the Research Portal, if citing you are again advised to check the publisher's website for any subsequent corrections.

General rights

Copyright and moral rights for the publications made accessible in the Research Portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognize and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the Research Portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the Research Portal

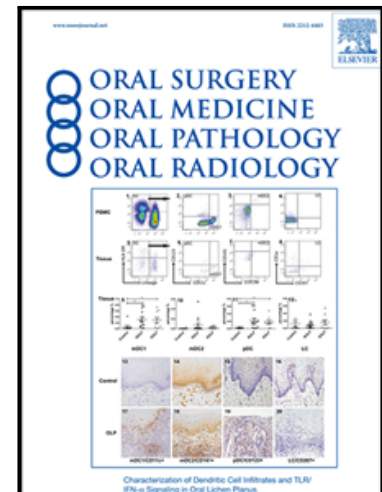
Take down policy

If you believe that this document breaches copyright please contact librarypure@kcl.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.

Coronectomy Root Retrievals: A review of 92 cases

Bizhan Shokouhi , Selvam Thavaraj , Chris Sproat , Jerry Kwok ,
Kiran Beneng , Vinod Patel

PII: S2212-4403(18)31164-7
DOI: <https://doi.org/10.1016/j.oooo.2018.09.001>
Reference: OOOO 2080



To appear in: *Oral Surg Oral Med Oral Pathol Oral Radiol*

Received date: 17 July 2018
Revised date: 26 August 2018
Accepted date: 3 September 2018

Please cite this article as: Bizhan Shokouhi , Selvam Thavaraj , Chris Sproat , Jerry Kwok ,
Kiran Beneng , Vinod Patel , Coronectomy Root Retrievals: A review of 92 cases, *Oral Surg Oral
Med Oral Pathol Oral Radiol* (2018), doi: <https://doi.org/10.1016/j.oooo.2018.09.001>

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Coronectomy Root Retrievals: A review of 92 cases

Bizhan Shokouhi, Selvam Thavaraj, Chris Sproat, Jerry Kwok, Kiran Beneng, Vinod Patel

Authors:

Bizhan Shokouhi

Senior Speciality Dentist in Oral Surgery
Oral Surgery Department
Guy's Hospital
Great Maze Pond
London
SE1 9RT
Email: bizhan.shokouhi@gstt.nhs.uk
Telephone: (+44) 020 7188 4397

Selvam Thavaraj

Consultant Oral Pathologist
Oral Pathology, Floor 4,
King's College London Dental Institute
Guy's Hospital
Great Maze Pond
London
SE1 9RT
selvam.thavaraj@kcl.ac.uk

Chris Sproat

Consultant Oral Surgeon
Oral Surgery Department
Guy's Hospital
Great Maze Pond
London
SE1 9RT
Chris.sproat@gstt.nhs.uk

Jerry Kwok

Consultant Oral Surgeon
Oral Surgery Department
Guy's Hospital
Great Maze Pond
London
SE1 9RT

Jerry.kwok@gstt.nhs.uk

Kiran Beneng

Consultant Oral Surgeon
Oral Surgery Department
Guy's Hospital
Great Maze Pond
London
SE1 9RT
Kiran.beneng@kcl.ac.uk

Vinod Patel

Consultant Oral Surgeon
Oral Surgery Department
Guy's Hospital
Great Maze Pond
London
SE1 9RT
Email: vinod.patel@hotmail.co.uk
Telephone: (+44) 020 7188 3885

Corresponding author: Vinod Patel – vinod.patel@hotmail.co.uk

Disclosures & Conflicts of interest - None

Abstract word count – 160

Manuscript word count – 3737

Number of references - 25

Number of figures/tables – 9 figures/1 table

Abstract

Background: Coronectomy has become an increasingly prescribed surgical treatment for mandibular third molars deemed to pose a risk to the inferior dental nerve. The retention of the roots can have subsequent potential for root retrieval in the future if symptoms are reported. The long term outcome and symptoms leading to coronectomy root retrieval have not been well documented or studied which has understandably led to hesitation by some clinicians offering the procedure. The current series assesses the patients who have undergone root retrieval and their reported indication for removal as well as the histopathological status of the removed roots.

Method: A total of 92 coronectomy root retrievals were carried out at Guy's Dental Hospital and included in this analysis. Data was collected retrospectively from patient

records regarding; patient symptoms, clinical and radiographic findings, function of the inferior dental nerve (IDN) and histological results.

Results: The mean age of patients in the study group was 31.6 years (range 19-70), with a female to male ratio of 62:18 (77.5% female). The mean time to the second surgery for root retrieval was 17.0 months. In 'successfully' performed coronectomies, 75.3% (n=61/81) of root pulps histopathologically appeared vital. Mucosal tenderness (39/81, 48.1%) was the most common symptom leading to root retrieval.

Conclusion: Root retrieval following coronectomy should be based on sound clinical and radiographic examination. Where obvious indications are present such as an unhealed socket due to retained enamel or soft tissue infection following eruption of the roots, then retrieval should be performed with confidence in resolution. However, if the coronectomy root appears an unlikely culprit, then the clinician should consider and investigate alternative diagnoses such as over erupted upper third molars causing trauma, temporomandibular dysfunction and the dental status of the adjacent tooth as potential causes of symptoms.

Keywords

Coronectomy, lower third molar, root retrieval, histopathology

Introduction

Coronectomy, or intentional partial odontectomy, is a procedure aimed at reducing the risk of inferior dental nerve (IDN) injury commonly associated with mandibular third molar (M3M) surgery (1, 2). It is beginning to gain popularity in clinical practice with an increasing body of evidence to support its efficacy (3-5) as well as increasing levels of litigation (6-8) creating a partial element of defensive dentistry.

A major concern of coronectomy is the lack of long-term evidence on the outcome of the retained roots. It is accepted that root migration occurs in the vast majority of cases. However, very few appear to penetrate the mucosa and the decision to retrieve the retained roots is multifactorial and is based on clinical, radiographic and patient factors. To correctly diagnose when root retrieval is indicated, a detailed understanding of these factors is required. In this case series we analyse these factors along with the histopathological status of the retrieved root, to allow for a better understanding of the symptoms that patients may present with post-coronectomy.

Method

Data was collected retrospectively from patients attending the Oral Surgery department at Guy's Dental Hospital, London. A total of 92 teeth, from 80 patients, were identified and consecutively collected between September 2011 and September 2016 (5 years).

All patients, except one, had their coronectomy procedure performed in our department. The original coronectomy procedures were carried out by different

clinicians within the department following the surgical protocols outlined by Gleeson et al (9). Following coronectomy, patients were either under review within the department or re-referred by their general dental practitioner with symptoms thought to be arising from the retained root. Following clinical and radiographic examination, if root retrieval was planned, patients were scheduled for surgery via the most appropriate anaesthetic method (local anaesthesia, local anaesthesia & intravenous sedation, general anaesthesia). All roots were retrieved via a standard approach of a buccal muco-perisoteal flap, bone removal if required, followed by elevation of the roots, wound toilet and closure with resorbable sutures. Post-operative antibiotics were provided only if the surgical site was infected at the time of the surgery (amoxicillin 500mg tds or metronidazole 400mg tds for those who there were penicillin allergic for 5 days). All patients were given review appointments at 4 weeks to check healing and resolution of symptoms. The retrieved roots were fixed in 10% (v/v) buffered formal saline for 48 hours then longitudinally hemisected using a diamond band saw, and decalcified in 10% (v/v) buffered formic acid. Where orientation was equivocal, roots were submitted whole for decalcification. Blocks of decalcified tissue were processed and embedded in paraffin wax. Whole decalcified roots were embedded *en face*. Sections of 5 µm were cut and mounted on slides coated with poly-L-lysine. They were deparaffinised in xylene, dehydrated in 100% (v/v) industrial methylated spirit, and rinsed in running tap water. All sections were routinely stained with haematoxylin and eosin and submitted for routine microscopy. Serial step sections were undertaken if the entire length of the root canal was not included in the plane of the index section.

Information was collected from patient records regarding reported symptoms, clinical and radiographic findings, function of the inferior dental nerve (IDN) and histological results to determine the most common indications for retrieval of coronectomy roots and to determine if errors in the original diagnosis or other factors could have contributed to the patient's symptoms.

Results

A total of 92 coronectomy roots were retrieved from 80 patients. All cases involved were mandibular third molars. The mean age of patients in this review was 31.6 years (range 19-70), with a female to male ratio of 62:18 (77.5% female) and a 1:1 ratio of left to right molars. The ratio for the angulation of teeth at original presentation is shown in Figure 1.

Cone beam CT (CBCT) was required in 15.2% (n=14/92) where plain radiography of the retained root suggested a close proximity to the IDN. 77.2% (n=71/92) of residual roots were deemed to be clear of the IDN at the time of retrieval and therefore did not require a CBCT. The mean time to the second surgery for root retrieval was 17.0 months (range 1-90). Figure 2 shows a more detailed breakdown of the time from coronectomy to root retrieval.

The cohort was split into 2 distinct groups of 'successfully' and 'unsuccessfully' performed coronectomy. The latter group consisted of those where retained enamel could be seen on the pre retrieval plain film or CBCT. Based on this categorization, 12.0% (n=11/92) of cases were found to have been performed unsuccessfully.

Figure 3 shows the documented diagnoses that resulted in the decision to plan for root retrieval.

All cases, except one, reported an improvement in their symptoms post-operatively and were either discharged or subsequently lost to follow up. The case that did not resolve following root retrieval was later found to have symptoms arising from an infected adjacent tooth.

Figures 4A and 4B shows a breakdown of the time frame post-coronectomy in which patients presented with each diagnosis. Figure 5 shows alternative diagnoses that may have contributed to symptoms at the time of root retrieval in the successfully performed coronectomy cohort based on the clinician's records. These were not the primary diagnoses used as an indication for root retrieval and this group does not include unsuccessfully performed coronectomies. Of the cases with mucosal tenderness, 46.2% (n=18/39) presented with an unopposed over-erupted upper third molar tooth on the side of the coronectomy (51.3% female dominance). 56.4% (n=22/39) had signs and symptoms suggestive of temporomandibular dysfunction (TMD) or myofascial pain (77.3% female dominance), including non-specific pain in the jaw that was not localised to the surgical site. Only 17.9% (n=7/39) of cases with reported mucosal tenderness did not have signs or symptoms of TMD or an unopposed over-erupted upper third molar.

Radiographic root morphology assessment found 75% (n=69/92) of roots were straight or conical. Six asymptomatic roots were removed as part of an overall treatment plan due to the patients receiving a general anaesthetic for the 'symptomatic' opposing side. All of these roots had migrated away from the IDN and were deemed to be of very low risk and were retrieved successfully.

Table 1 summaries the histological findings of all the roots retrieved. In the 'successfully performed' coronectomies, 75.3% (n=61/81) of root pulps were found to be vital and uninflamed, 2.5% (n=2/81) were vital with features of pulpitis, 16.0% (n=13/81) were partially vital without peri-radicular inflammation, 5% (n=4/81) were partially vital with peri-radicular inflammation and 1.2% (n=1/81) were non-vital without peri-radicular inflammation. In the unsuccessful coronectomy group, 54.5% (n=6/11) of root pulps were found to be vital and uninflamed, 18.2% (n=2/11) were vital with signs of pulpitis and 27.3% (n=3/11) were non-vital without peri-radicular inflammation. Photomicrographic examples of uninflamed vital pulp, non-vital pulp and peri-radicular inflammation are illustrated in Figures 6 and 7.

Of all of the roots without a vital and healthy pulp, 64% (n=16/25) were found to be above the crestal alveolar bone level, as observed on the pre-root retrieval radiograph, whilst the remaining 36% (n=9/25) appeared to be covered by bone.

Discussion

In the last decade, coronectomy has gained popularity as a treatment option for mandibular third molars deemed to be in close proximity to the IDN. As part of consent, patients should be informed that the retained root may erupt and require removal. The reported incidence of root eruption is approximately 3% (5). Despite the increasing evidence for the value of coronectomy the clinical uptake is still

generally poor with one of the most commonly stated reasons being concern over long-term status of the retained root. It is widely accepted that retained roots are not necessarily a source of symptoms, with support in the literature showing that 11-20% of the population present with retained tooth roots during routine investigations (11-13). As coronectomy is performed on healthy teeth the retained roots should pose less of an issue than those from erupted teeth which are commonly related to a long-term pathological process associated with caries or an extra-coronal restoration.

Regardless of the surgeons' personal prescription habits for coronectomy, as the procedure is performed more frequently, a better understanding is needed for when root retrieval is indicated. This case series analyses our findings from a large cohort of coronectomy root retrievals over a period of 5 years. The total number of coronectomy procedures carried out in this period within the department was approximately 1400. The number of patients who have presented in this period is not necessarily indicative of the actual incidence of root retrievals, as patients may have attended elsewhere to have the retained roots removed but it gives an overview of the most common issues.

Indications for root retrieval

Within this cohort, patients presented with a wide range of signs and symptoms that subsequently led to root retrieval. Routine indications for removal of any retained roots is often due to pain, inflammation, trauma of the surrounding soft tissue or infection and within this series coronectomy roots also presented with the same issues. Identifying if the coronectomy root is the cause of the presenting symptoms is important to prevent unnecessary root retrieval. In certain situations this is straightforward, for example, when the roots had become partially erupted, reflecting the patient's reported symptoms of food trapping and mucosal tenderness. The ideal option is root retrieval. However, if this is deemed to place the IDN at risk of injury then a re-operation for further root reduction may be considered. In most cases the consequential root migration is seen as advantageous due to the roots moving away from IDN and so re-operation for further reduction is a rare event. In a small sub-cohort of patients, a pragmatic approach was undertaken to avoid a potential second re-operation under a general anaesthetic by removing asymptomatic and low risk coronectomy roots on the contralateral side uneventfully.

The most commonly reported symptom leading to root retrieval was mucosal tenderness, which in the absence of other clinical signs is a vague symptom. Migrating roots can be seen radiographically at crest without clinical signs of having breached the mucosa, however, this could be a cause of mucosal tenderness as the roots are superficially below a thin layer of mucosa. A clear trend can be seen in Figure 4A which shows an increasing incidence of mucosal tenderness related to time since operation, which would be expected due to migration. Mucosal tenderness with apparent lack of exposed root could occur where parts of the root surface may not be completely smooth and an area is prominent causing a micro-perforation. Such areas tend to particularly occur in disto-angular teeth on the mesio-lingual aspect where direct vision for smoothing can be compromised.

Post-operative infection due to the retained root is a reported major concern following coronectomy. To date, there is no evidence to show an increased risk of

post-operative infection following coronectomy when compared to third molar extraction. Unfortunately, a presenting infection following coronectomy is often 'blamed' on the retained root when it is most likely to be a surgical site infection. Within this series, two cases (2.2%) presented with a facial swelling within one week of the coronectomy procedure. Subsequently, root retrieval was undertaken with the surgical site left open for drainage. Oral antibiotics were prescribed and both roots were sent for histopathological assessment and were found to have vital pulps making surgical site infection the most likely cause. Of note, both cases had signs of an acute infection associated with the third molar on the day of the surgery. The surgical protocol within the department does not call for the prescription of routine post-operative antibiotics due to the lack of evidence for their efficacy. However, in the presence of any signs indicative of a peri-operative acute infection, it is recommended that antibiotics are prescribed or the treatment delayed until the infection has been resolved.

A retrospective scrutiny of indications for root retrieval under the 'mucosal tenderness' category where the roots were radiographically beneath crestal bone was performed to determine if an alternative diagnosis could be responsible for the reported symptoms. Possibilities included pulpitis of the retained root, over eruption of the opposing tooth, myofascial pain related to TMD and pulpitis or apical periodontitis in adjacent teeth. Pulpitis may lead to symptoms from the retained root which often causes poorly localised episodic pain. Its occurrence in an unerupted root with no communication with the oral cavity could be related to acute trauma to the healthy pulp from the procedure itself, a dry socket or from the medicaments used to treat this, as highlighted in a case by Patel et al (10). Post-coronectomy, the retained root is normally covered by a blood clot and the sutured oral mucosa provides a good environment for neo-vascularisation and pulpal protection. In contrast, it has been reported that up to 9% of teeth lose their vitality following an extra-coronal restoration (14) with the most likely cause being microbial threat to the pulp from the oral flora (15).

Over-eruption of the unopposed upper third molar, which can be easily assessed both clinically and radiographically (Figure 8), may cause direct mucosal trauma over the coronectomy site. In such a situation it would be wise to extract the upper third molar before considering root retrieval.

TMD is a common condition affecting a reported 26% of the general population in the UK (16), with some evidence of it developing following third molar surgery (17). The incidence of TMD is higher in females who are also more likely to present themselves for third molar treatment (18). When there are vague symptoms of 'jaw pain' post-coronectomy, TMD could be a reasonable differential diagnosis to consider. This may have been a pre-existing condition, a simultaneous occurrence or secondary to the third molar surgery. Patel et al (10) series highlighted that the initial diagnosis prior to coronectomy may have been incorrect with TMD being the most likely alternative. Interestingly however, all patients except one reported symptom resolution post root retrieval or were lost to follow up suggesting resolution making TMD less likely.

Surgical technique

The specific surgical techniques for coronectomy have been well documented (2, 9, 19). The procedure is technique sensitive and if meticulous care is not taken then failure is more likely. It is essential for the retained root surface to be reduced at least 3mm below the crestal bone level, with no retained enamel. Studies have shown that root migration occurs at a level of between 3.4mm at 6 months to 4mm at 24 months (20) and that this rate is highest within the first 6 months (21). Hence the recommendation of a minimum root reduction of 3mm below the crestal bone height is to compensate for the expected average subsequent migration in the short-term post-coronectomy, as well as providing enough space for the roots to clear the IDN if eruption occurs. Reduction below this height will also allow for an osteodentine bridge formation. If root reduction is less than 3mm or in individual cases where there has been rapid migration leading to eruption, there is a higher risk of the roots becoming partially erupted leaving them exposed to the oral flora and bacteria. This may in turn increase the risk of developing pulpitis or loss of vitality of the pulp.

Another technique sensitive part of the coronectomy procedure is the decoronation. The suggested technique varies however, the most common technique involves a partial section with a rotary handpiece and completed by decoronating with an elevator. An inadequate cut, excessive force, or both, can lead to undesirable luxation forces on the root which may cause a disturbance in the cementum and contribute to increased migration of roots (10, 22), or worse still mobilise the roots requiring peri-operative retrieval. The pulpal status of potentially luxated coronectomy roots remains unknown but may explain why patients occasionally report symptoms when radiographically the root appears disease free and deeply buried. In a similar way erupted teeth affected by traumatic luxation injuries including displacement are not always immediately rendered non-vital. Based on this, if pulps are able to survive in such severe impact trauma then in comparison, elective and controlled luxation should lower the risk of pulpal devitalisation.

Thermal damage to the pulp is also a potential factor that might be significant during decoronation. Temperatures above 42.5°C can cause irreversible damage to the pulp (15) and it has been reported that a surgical drill at 20,000RPM, even with copious irrigation, can reach temperatures of 89°C within 0.5mm of the drill hole (23). This could be significant in coronectomy as the decoronation and root face smoothing are all completed with a handpiece directly contacting the pulp. Hence during peri- and post-decoronation, it is likely that there is thermal stress to the pulp and if this does not resolve, it could progress to irreversible pulp damage and subsequent periapical inflammation. Radiographically this should present with apical radiolucency, which was not apparent in our series. It is important to consider this when performing the procedure and to try to reduce the thermal impact by adequate cooling of the drill and an incremental cutting approach to ensure the tip of the bur is irrigated.

Finally, the surgical site should be closed primarily and tension-free to stabilise the blood clot and protect the root from the oral environment. Where there is alveolar osteitis 'excessive' packing and dressing with Alveogyl™ (Septodont, Maidstone, UK) can cause wound breakdown (10) exposing the root to ingress of bacteria which places it at risk (24).

Root pulp vitality

This series shows that 75.3% of pulps remained vital in a 'successful' coronectomy and this was reduced to 54.5% in an 'unsuccessful' coronectomy. This may be explained by the retained enamel exposing the pulp to the oral flora.

When both groups were combined including those with signs of an inflamed, partially vital (differing pulpal status in multi-rooted teeth, Figures 6 and 7) or non-vital pulps, 64% (16/25) of roots were found to be above the crestal bone level and hence able to communicate with the oral cavity.

The partial vitality of roots was an interesting finding and unfortunately at the macroscopic and microscopic stages it was impossible to determine the mesio-distal orientation of the tooth, however, it is conceivable that the pulp in one root has undergone pulpitis or pulpal death where it has become exposed to the oral flora while the other root remains buried (Figures 6 and 7). Our departmental coronectomy technique to avoid separating the roots by smoothing to the base of the pulp chamber leaving the roots joined by the pulpal floor dentine and with pulp retained individually in each root unconnected to one another. Even though pulpal exposure to the oral cavity has been postulated as a reason for pulpal death, this is not always the case as not all the unsuccessful coronectomy cases showed devitalisation. Patel et al (10) highlighted a case where a constantly stimulated pulp led to reactionary dentine formation to produce a protective barrier for the pulp.

Time frame of post-operative signs and symptoms

Analysis of the time frame for root retrieval in this series highlights two distinct phases for root retrieval (Figure 2). Root retrieval in the short term (within 1 year of coronectomy) is most commonly related to an 'unsuccessful' coronectomy with the retention of enamel and failure to heal. Any operation not performed correctly is open to failure and it appears that coronectomy is no different and sensitive to small operator errors including retention of enamel or excessive force in decoronation. Enamel retention is not exclusive to short-term failure and can lead to pocketing and wound breakdown (Figure 4B), but this is usually within 5 years post-coronectomy. In contrast, root retrieval as a late consequence, more than 5 years post-coronectomy, appears to be most commonly related to migration.

The impact of root morphology and tooth angulation

Tooth eruption is thought to be driven via root formation and a bone remodelling process through osteogenesis and osteoclast-mediated remodelling (25) and it is likely these factors will have some involvement in the root migration and eruption process. Initially post-coronectomy, there is no coronal bone to be remodelled and so there is less resistance, which may in turn strengthen the role of other factors during root migration. 75% (n=69/92) of the retained roots that were retrieved were found to have non-complex root morphology (straight or conical root morphology without any curvatures or dilacerations) and this would appear to be a significant risk factor for roots that may require retrieval. Teeth with divergent or bulbous root form seem to be more resistant to eruption forces and more likely to remain submerged.

Additionally, the angulation of the tooth prior to coronectomy appears to have an impact on the incidence of retrieval. Vertically or mesially angulated mandibular third

molars were at most risk, whereas horizontally angulated teeth had the least incidence of retrievals. It appears that if a root can easily reach the surface the incidence of retrieval increases. Achieving ample root surface reduction below crestal bone in a fully erupted third molar is more difficult without separating the roots which is not generally recommended.

Conclusion

Coronectomy remains a useful treatment option for the management of mandibular third molars 'at risk' of IDN injury with a low incidence of roots requiring retrieval. Of the roots retrieved, there were no long term post-operative complications. With the likelihood of an increase in the number of coronectomies being carried out in the coming years, it is vital that clinicians are able to identify the signs and symptoms that may arise from the retained roots as well as those that may be related to other dental or jaw related diagnoses. A good history followed by clinical and radiographic examination is key in determining this. Our data suggests that after 5 years post-coronectomy, symptoms are unlikely to be related to pathological processes. Where the clinician doubts whether the coronectomy root is the potential cause of the reported symptoms, common alternative diagnoses to consider include TMD, over erupted and non-functional upper third molars causing trauma, and furthermore the vitality and dental status of the adjacent teeth should be investigated as appropriate.

Limitations

The authors recognise the limitations surrounding this series based on a retrospective analysis. However, this case series of coronectomy root retrievals is the largest cohort published in the literature and therefore provides some useful insight into a growing technique where little data or information is available. Preferably, a controlled prospective study would allow for a stricter data collection protocol and further research is warranted in this regard to increase our knowledge and understanding of this topic.

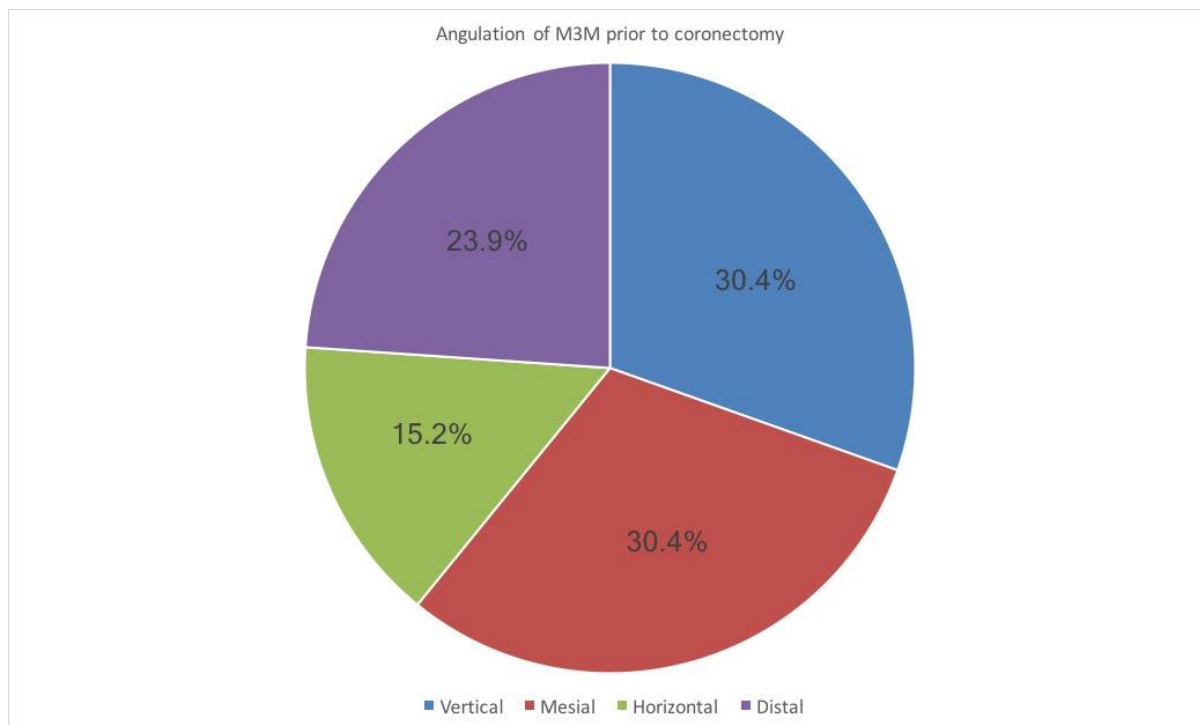
Figures

Figure 1: Angulation of mandibular third molars prior to coronectomy

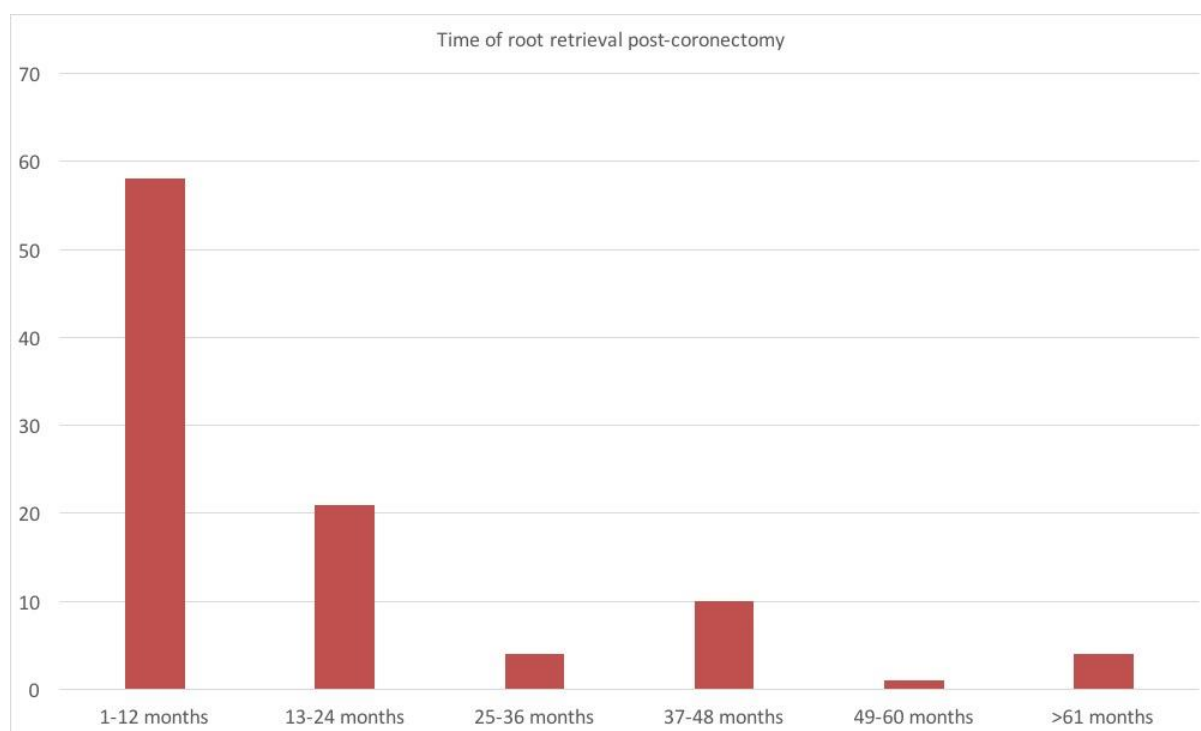


Figure 2: Time of root retrieval post-coronectomy

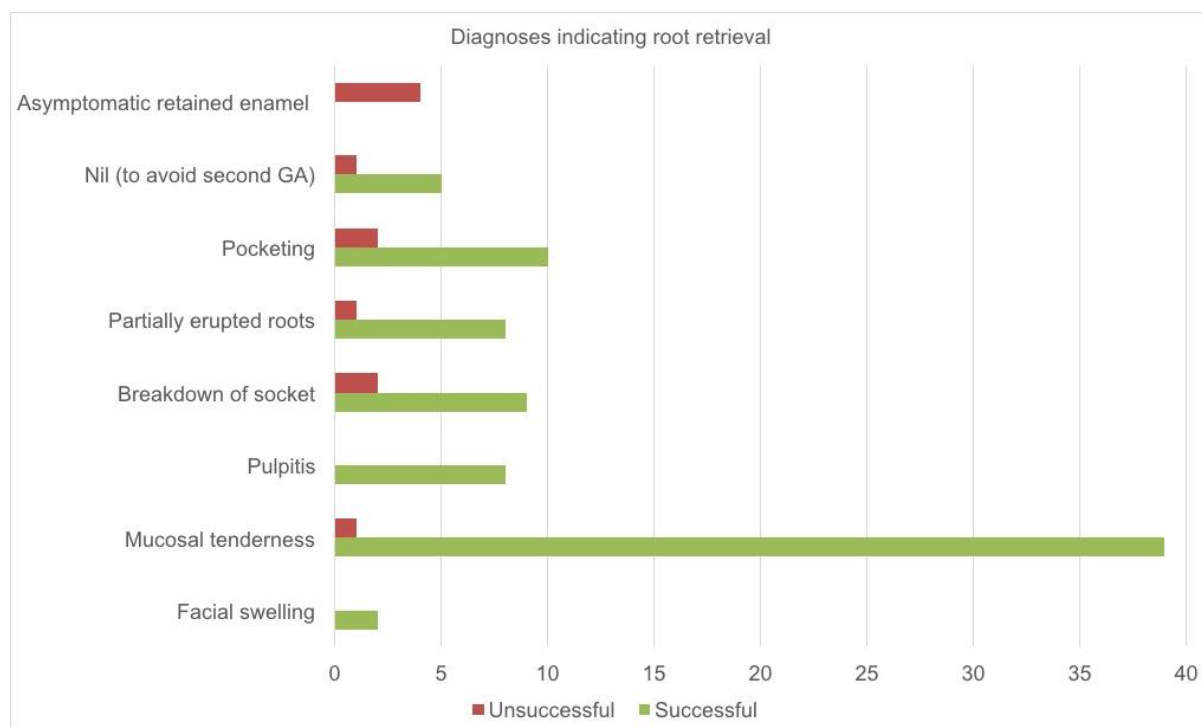


Figure 3: Number and diagnoses indicating root retrieval for successfully and unsuccessfully performed coronectomies

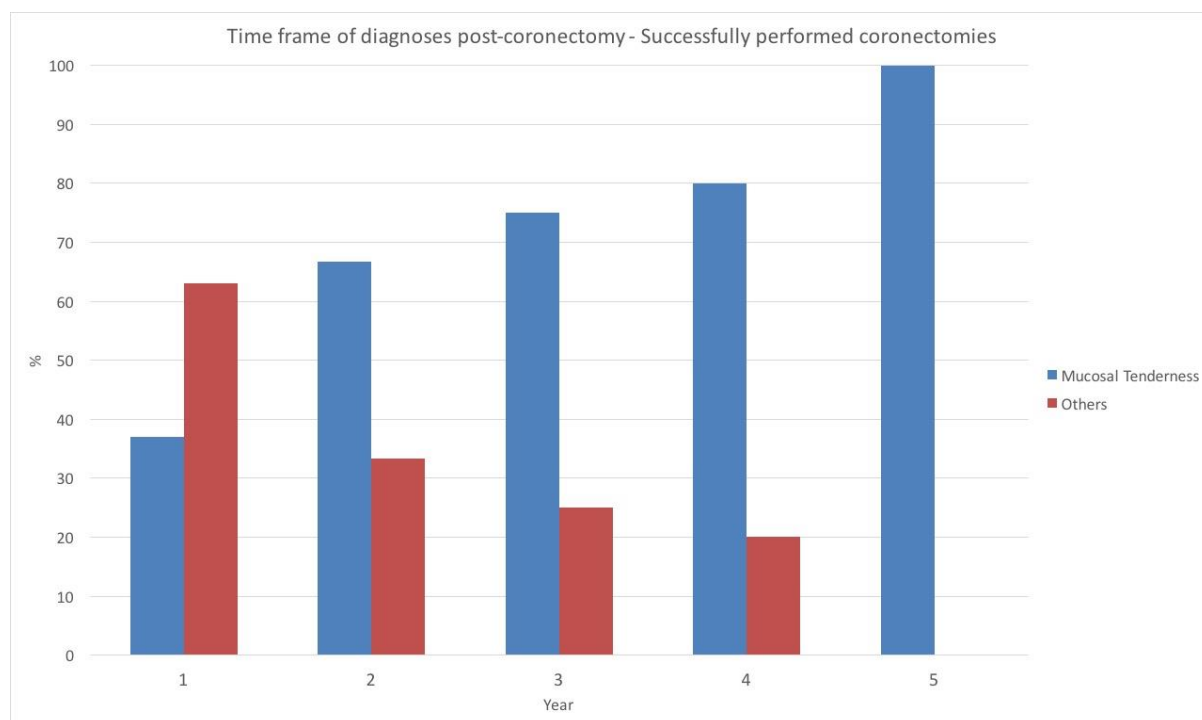


Figure 4A: Time frame of diagnoses post-coronectomy: Successfully performed coronectomies

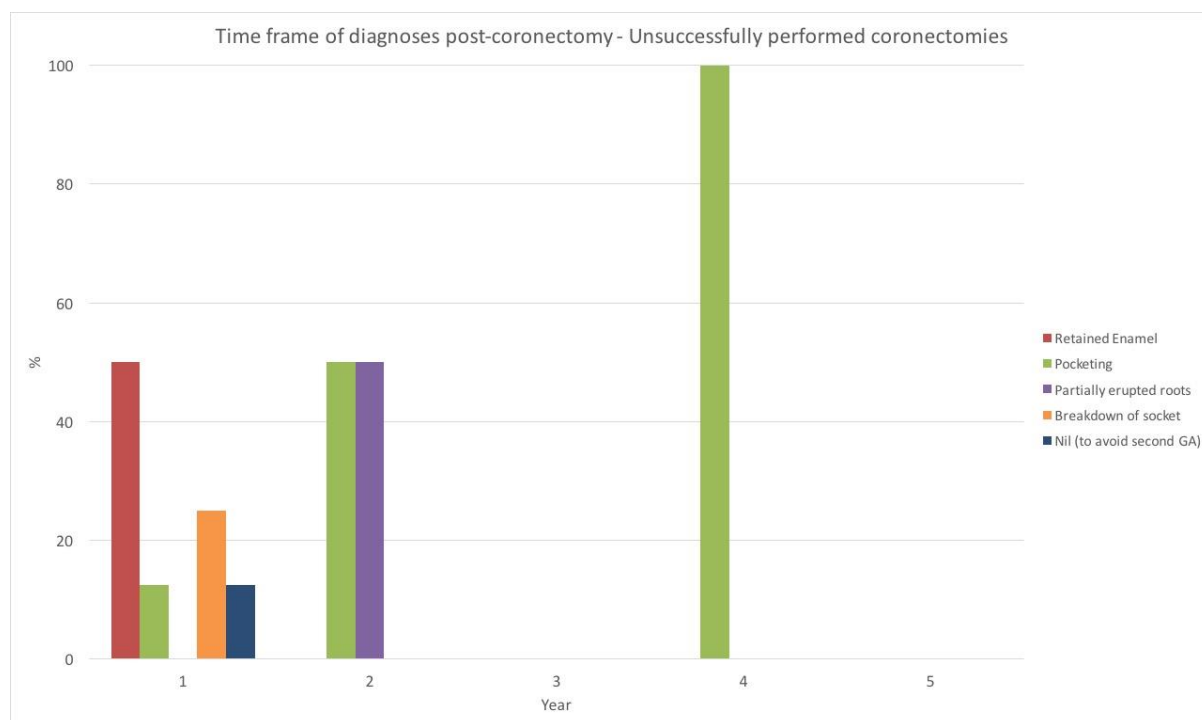


Figure 4B: Time frame of diagnoses post-coronectomy: Unsuccessfully performed coronectomies

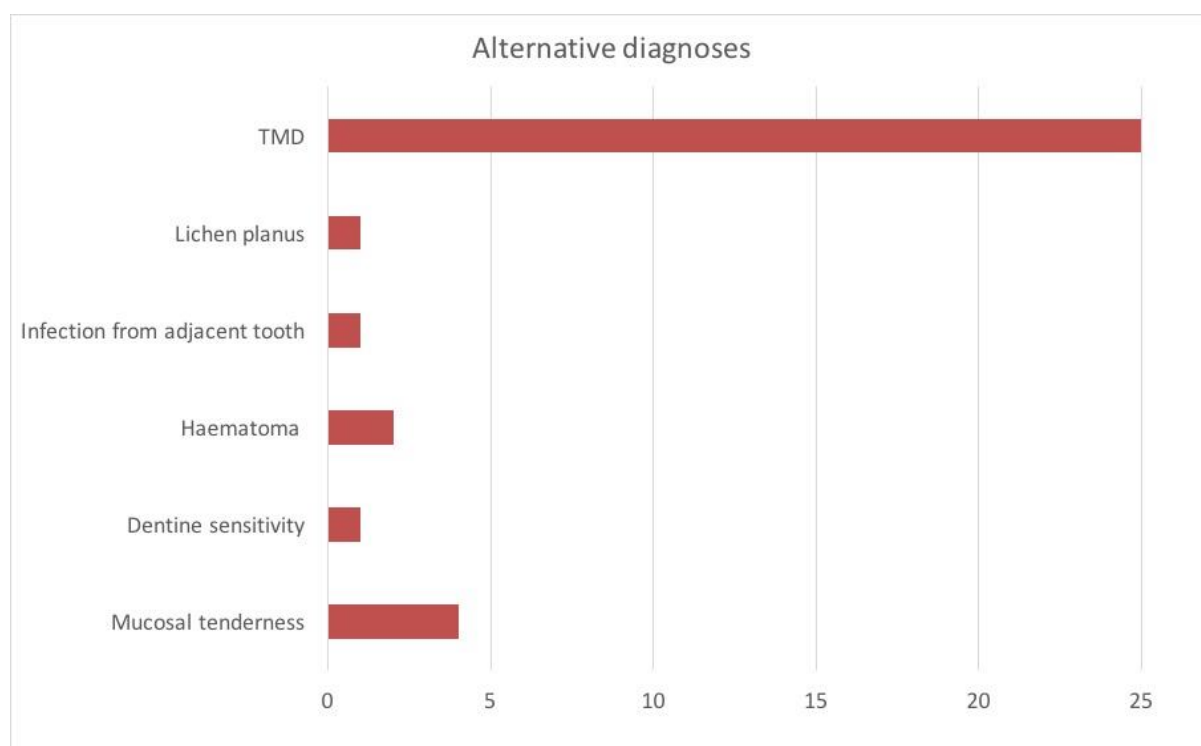


Figure 5: Alternative diagnoses at time of assessment for root retrieval

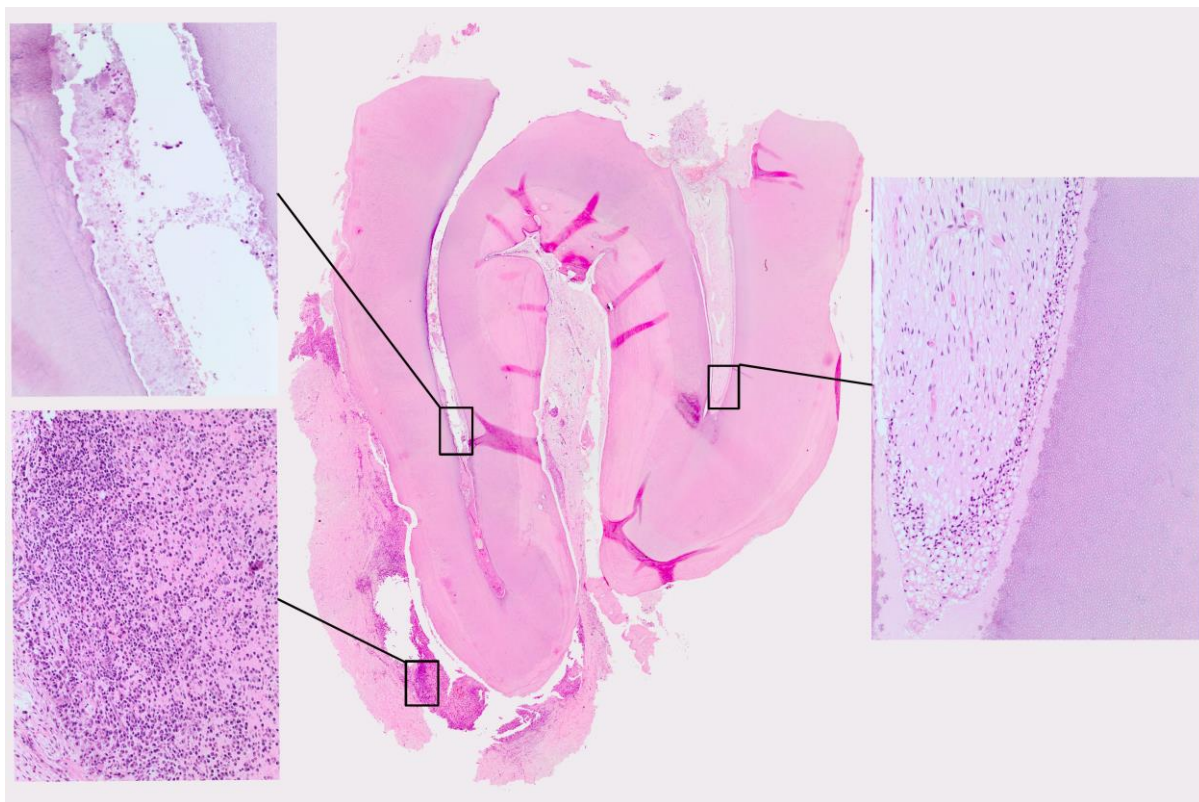


Figure 6: Composite photomicrograph of longitudinally sectioned roots. Whole-mount depicted centrally. Insets are medium power views. Top left: necrotic pulp. Bottom left: chronically inflamed peri-radicular fibrous tissue. Right: uninfamed vital pulp.

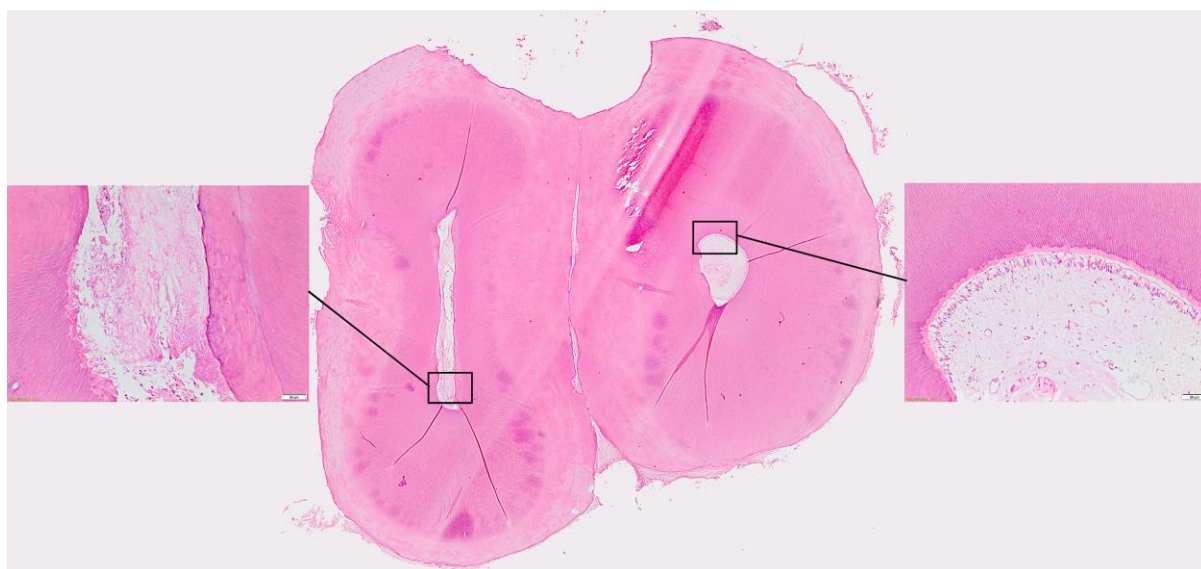


Figure 7: Composite photomicrograph of transversely sectioned roots. Whole-mount depicted centrally. Insets are medium power views. Left: necrotic pulp. Right: uninfamed vital pulp.



Figure 8: Example of buried retained roots in the presence of an over-erupted opposing upper third molar

Table

Table 1: Histological status of successfully and unsuccessfully performed coronectomies

Conflicts of interest

Nil to declare

Financial disclosures

Nil to declare

Ethical approval

N/A

Clinical Relevance

Coronectomy is gaining popularity for mandibular third molar surgery however there remains reservation from some regarding the pathological status of the retained root. This study provides an insight into this current and relevant procedure.

References

1. Knutsson K, Lysell L, Rohlin M. Postoperative status after partial removal of the mandibular third molar. *Swedish dental journal*. 1988;13(1-2):15-22.
2. Pogrel MA, Lee J, Muff D. Coronectomy: a technique to protect the inferior alveolar nerve. *Journal of oral and maxillofacial surgery*. 2004;62(12):1447-52.
3. Leung YY, Cheung LK. Safety of coronectomy versus excision of wisdom teeth: a randomized controlled trial. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology*. 2009;108(6):821-7.
4. Leung YY, Cheung LK. Coronectomy of the lower third molar is safe within the first 3 years. *Journal of Oral and Maxillofacial Surgery*. 2012;70(7):1515-22.
5. Leung YY, Cheung LK. Long-term morbidities of coronectomy on lower third molar. *Oral surgery, oral medicine, oral pathology and oral radiology*. 2016;121(1):5-11.
6. Bright E, D'Cruz L, Milne E. Consent—an update. *British Dental Journal*. 2017;222(9):655-7.
7. Hupp JR. Legal implications of third molar removal. *Oral and maxillofacial surgery clinics of North America*. 2007;19(1):129-36.
8. Williams M, Tollervey D. Lower third molar surgery—consent and coronectomy. *British dental journal*. 2016;220(6):287-8.
9. Gleeson CF, Patel V, Kwok J, Sproat C. Coronectomy practice. Paper 1. Technique and trouble-shooting. *British Journal of Oral and Maxillofacial Surgery*. 2012;50(8):739-44.
10. Patel V, Sproat C, Kwok J, Beneng K, Thavaraj S, McGurk M. Histological evaluation of mandibular third molar roots retrieved after coronectomy. *British Journal of Oral and Maxillofacial Surgery*. 2014;52(5):415-9.
11. Dachi SF, Howell FV. A survey of 3,874 routine full-mouth radiographs: I. A study of retained roots and teeth. *Oral surgery, Oral medicine, Oral pathology*. 1961;14(8):916-24.
12. Bayanzadeh M, Shokri S. Radiographic evaluations of patients seeking removable prostheses treatment. *Journal of Dental Medicine*. 2003;16(4):78-81.
13. Kharat D, Saint T. Embedded root fragments in completely and partially Edentulous jaws. 1991.
14. Bergenholtz G, Nyman S. Endodontic complications following periodontal and prosthetic treatment of patients with advanced periodontal disease. *Journal of Periodontology*. 1984;55(2):63-8.
15. Whitworth J, Walls A, Wassell R. Crowns and extra-coronal restorations: endodontic considerations: the pulp, the root-treated tooth and the crown. *British dental journal*. 2002;192(6):315.
16. Macfarlane TV, Blinkhorn AS, Davies RM, Kincey J, Worthington HV. Oro-facial pain in the community: prevalence and associated impact. *Community dentistry and oral epidemiology*. 2002;30(1):52-60.
17. Juhl GI, Jensen TS, Norholt S, Svensson P. Incidence of symptoms and signs of TMD following third molar surgery: a controlled, prospective study. *Journal of oral rehabilitation*. 2009;36(3):199-209.

18. Huang GJ, LeResche L, Critchlow C, Martin MD, Drangsholt MT. Risk factors for diagnostic subgroups of painful temporomandibular disorders (TMD). *Journal of dental research*. 2002;81(4):284-8.
19. Patel V, Gleeson CF, Kwok J, Sproat C. Coronectomy practice. Paper 2: complications and long term management. *British Journal of Oral and Maxillofacial Surgery*. 2013;51(4):347-52.
20. Dolanmaz D, Yildirim G, Isik K, Kucuk K, Ozturk A. A preferable technique for protecting the inferior alveolar nerve: coronectomy. *Journal of Oral and Maxillofacial Surgery*. 2009;67(6):1234-8.
21. Cheung K, Leung Y. Long-term analysis of root migration after third molar coronectomy. *International Journal of Oral and Maxillofacial Surgery*. 2017;46:106.
22. Renton T. Notes on coronectomy. *British dental journal*. 2012;212(7):323-6.
23. Eriksson AR, Albrektsson T, Albrektsson B. Heat caused by drilling cortical bone: temperature measured in vivo in patients and animals. *Acta Orthopaedica Scandinavica*. 1984;55(6):629-31.
24. Nayyar J, Clarke M, O'sullivan M, Stassen L. Fractured root tips during dental extractions and retained root fragments. A clinical dilemma? *British dental journal*. 2015;218(5):285-90.
25. Wise G, King G. Mechanisms of tooth eruption and orthodontic tooth movement. *Journal of dental research*. 2008;87(5):414-34.

	Successfully performed coronectomy (n=81)	Unsuccessfully performed coronectomy (n=11)
Vital & uninflamed	61 (75.3%)	6 (54.5%)
Vital & pulpitis	2 (2.5%)	2 (18.2%)
Partially vital (no peri-radicular inflammation)	13 (16%)	-
Partially vital (peri-radicular inflammation)	4 (5%)	-
Non vital (no peri-radicular inflammation)	1 (1.2%)	-
Non vital (peri-radicular inflammation)	-	3 (27.3%)

Table 1: Histological status of successfully and unsuccessfully performed coronectomies